



Development of Interactive Flipbook Media to Enhance Science Literacy Based on Sustainable Lifestyle in Elementary Schools

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Abstract

This study is motivated by the urgency of rapid digitalization in the 21st century, which necessitates the development of innovative, interactive, and contextual learning media. The purpose of this research is to develop a flipbook-based learning medium that integrates sustainable lifestyle values to enhance science literacy among elementary school students. The study employed the ADDIE development model comprising Analysis, Design, Development, Implementation, and Evaluation through stages that included needs analysis, media design, product development, classroom implementation, and evaluation. Data were collected through surveys, interviews, observations, and tests involving fifth-grade students from eight elementary schools in Medan City. The results indicate that the developed flipbook met the criteria of validity, practicality, and effectiveness based on expert validation and classroom implementation tests. The flipbook, which incorporates learning materials, simulations, evaluations, animations, and interactive visuals, effectively stimulates students' learning motivation and improves their science literacy skills. A novel finding of this study is the integration of science literacy with sustainable lifestyle values, which not only introduces scientific concepts but also instills positive habits for environmental preservation and social responsibility from an early age. The discussion emphasizes that the use of flipbook media can serve as an innovative alternative for teachers in science learning at the elementary level. This research produces an empirically tested flipbook medium and a teacher's instructional guide, thereby contributing to the advancement of educational science and the practice of sustainable education.

Introduction

21st-century education emphasizes the integration of critical thinking, creativity, collaboration, and communication skills, as well as the use of innovative technology to create learning that is relevant to the needs of students (Isabirye et al., 2025; Mugabekazi et al., 2025; Haryaka et al., 2025). One learning media innovation that is relevant to the needs of 21st-century education is the flipbook. A flipbook is an interactive digital book that can be accessed through electronic devices (Fadhilah & Adibah, 2025; Munajah & Anggraini, 2025; Haryudo et al., 2025). Flipbooks contain multimedia elements such as animations, videos, images, and audio. These elements not only make learning more interesting but also increase student engagement and support their various learning styles. Similarly, the use of flipbooks in IPAS learning on the subject of norms in my regional customs can improve student learning outcomes (Nabila et al., 2025). The use of flipbooks as a learning medium can also make the learning process more practical and enjoyable (Panggabean et al., 2023; Sylvia & Ponidi, 2025; Andreas et al., 2025).

Science literacy is very important in this digital era of 21st-century learning, where science literacy can be useful for individuals to critically evaluate information and make the right decisions. Science literacy enables a person to understand, analyze, and apply scientific concepts in everyday life (Sinaga et al., 2024; Soleha & Ariefka, 2026; Rusmansyah et al., 2026).

Flipbooks can improve science literacy and enhance the quality of learning by incorporating sustainable lifestyles into the learning process. This can be done by understanding global issues and the challenges that arise every day. Thus, the existing learning process can be applied to everyday life (Putra et al., 2023; Pehkonen et al., 2026; Danial et al., 2026). The early integration of sustainable lifestyles is very important in elementary schools because this is a phase that determines children's development (Al-Barakat et al., 2026; Stavreva Veselinovska et al., 2025; Eryaşar & Özel, 2025). During this phase, attitudes and fundamental values are formed that will have a significant impact on future life with the environment (Lestari et al., 2023). A sustainable lifestyle encourages students to care for the environment, such as bringing their own food and drink containers as an example of reducing waste; this can become a positive habit that leads to a sustainable lifestyle (Nurwidiyanti & Sari, 2022; Santosa et al., 2024). A sustainable lifestyle also requires students to be active in preserving the environment through educational activities and environmental campaigns (Ludin et al., 2025; Saktilia & Wulandari, 2024; Meherali, 2025).

Based on initial observations conducted in 8 elementary schools in Medan, learning in elementary schools is still centered on the use of pictures and printed books as learning media. Learning is still in the realm of remembering, understanding, and applying. Meanwhile, analyzing, evaluating, and creating new ideas are still neglected. This results in low science literacy among students, who are not yet able to think critically about the problems presented. Thus, there is a great need for media that is suitable for the 21st century, namely flipbooks, which are designed to make it easier for students to understand the material and improve their critical thinking. Flipbook media can be accessed on students' devices.

This study has the main objective of designing, testing the feasibility, and assessing the effectiveness of flipbook media in improving the science literacy of elementary school students based on a 21st-century sustainable lifestyle. This objective is in line with the research questions posed, namely how the flipbook design can be developed appropriately, how feasible it is in terms of content, appearance, and pedagogy, and how effective it is in the learning process. With this connection, the research is directed not only at producing learning media products but also at empirically proving their benefits in improving students' science literacy skills (Mafarja et al., 2025; Khoirunisa & Sukardi, 2025; Nurrahmah & Afrita, 2025).

The benefits of this research can be seen from several aspects. Theoretically, the research is expected to contribute to the development of science in the field of education, particularly technology-based learning models that support 21st-century competencies. Practically, the flipbook developed can be an alternative learning medium that is interesting, easy to use, and relevant to the needs of students. For teachers, this flipbook can be a solution in creating more interactive and contextual learning, while for students, the use of flipbooks can foster curiosity, critical thinking skills, and awareness of the importance of a sustainable lifestyle (Supriatna et al., 2025; Rida et al., 2025; Asiah et al., 2025). Thus, the relationship between the objectives, problem formulation, and benefits of this research is closely intertwined in order to produce learning innovations that are widely beneficial (Zhuang & Kimura, 2025; Song et al., 2025; Zhang et al., 2025).

According to experts, in the 21st century, media greatly assists in learning, making it interactive and enjoyable. Flipbook learning media is very effective and can be used in the learning process to improve students' science literacy and learning outcomes. Flipbook media with the teaching materials presented is very suitable for application in digital learning in elementary schools (Maureen et al., 2024). Flipbook media can assist students and teachers in the learning process and improve students' science literacy skills, where flipbooks can be used as an innovation in the learning process that is very much needed by students in understanding the material through innovative, creative, and informative media and improving student learning outcomes. It can also become a new learning media reference that can support the learning process in the 21st century (Trinova et al., 2025; Trisnawati et al., 2025; Nurhasanah et al., 2025).

Unlike previous studies that focused on increasing children's creativity, this study focuses on the effects of digital animation media on learning outcomes (Khofi, 2024; Zhou et al., 2025; Odogwu, 2025). This study presents interactive approaches such as animation, simulation, and educational game-based activities, which are tailored to the learning styles of students, where learning with flipbook media can improve science literacy based on a sustainable lifestyle. In this way, students gain knowledge and develop new behaviors that have a positive impact on society.

Methods

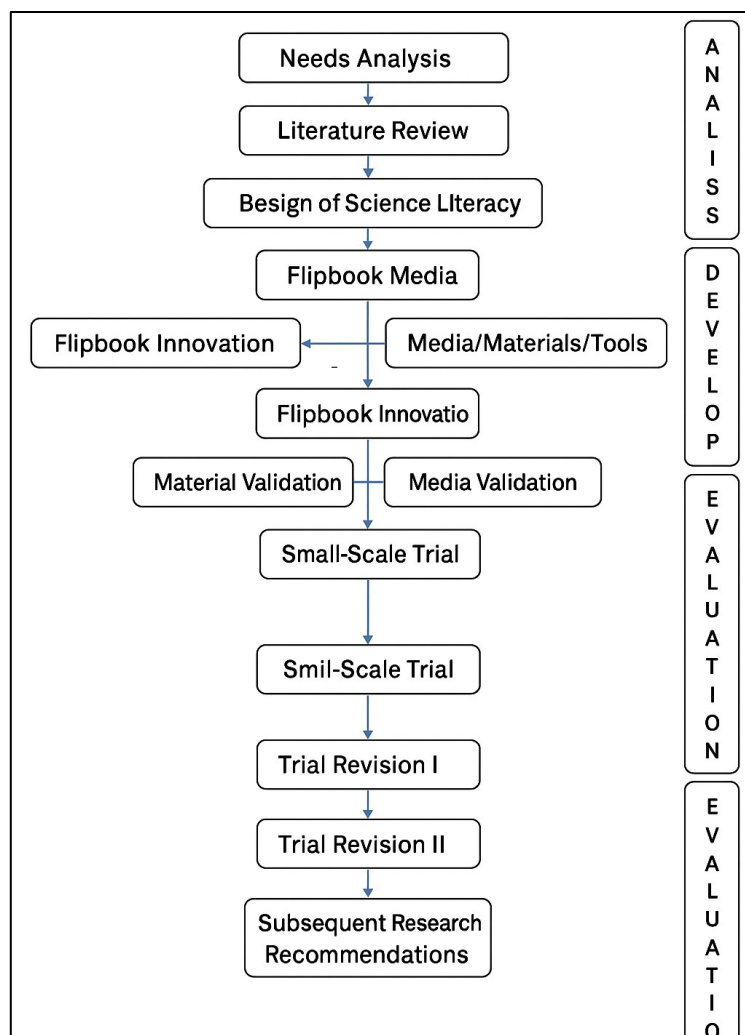


Figure 1. Flowchart of the ADDIE Model in Developing Interactive Flipbook Media for Science Literacy

The current study adopted a research and development paradigm based on ADDIE model which includes the following successive stages: Analysis, Design, Development, Implementation, and Evaluation. This model has been chosen due to the fact that it provides a very flexible and at the same time systematic model of the construction of instructional media that is both sensitive to the exigencies of the situation and also oriented towards pedagogical goals. Under such a methodological approach, the study did not simply strive to create a digital learning product; instead, it also tried to make the final product of the flipbook educationally substantive, empirically substantiated and practical in the school environment, in the elementary school. The cyclic character of the ADDIE model allowed reflecting on every step and improving the product during ongoing reflection on the theoretical requirements and evidence in the field.

The analysis stage was the starting point of the research process whose task was to determine the true state of science education and how science literacy has been created in the students at the elementary schools. This was the point at which the classroom observations, teacher interviews as well as initial questionnaires were conducted in eight elementary schools within the Medan City. Such practices were focused on the analysis of the access to learning media, existing instructional patterns, student engagement rates, and incorporation of values of sustainable lifestyle into the science education. The results indicated that teaching methods were mostly dependent on print books and fixed visual information, thus limiting the experience of discovery, critical thinking and situational use. In addition, educators have indicated that they had a problem in the presentation of science concepts that were interesting and close to the everyday life of students. These are the empirical observations, which were used as a foundation to state the instructional needs that were utilized in the study.

Based on the findings of the needs analysis, the research then moved to the design phase that focused on the systematic planning of the learning content, the learning flow, and the media format. The objectives of learning were created according to the science literacy indicators and the standards of the curriculum applied in elementary school. At the same time, the values of sustainable lifestyle were intentionally integrated in scientific topics to make sure that the conceptual integration and not superficial integration is observed. An in-depth storyboard and flow chart was created to help sequence learning resources, interactive elements, formative assessment and reflection exercises. Special emphasis was put on visual arrangement, navigation schemes, and legibility to support the learning and cognitive abilities and developmental levels of elementary school students. It is in this design process that the flipbook was not only imagined as a digital textbook but as a learning environment that is mobile and allows one to inquire and reflect.

At the end of the design blueprint, the study proceeded to the development phase whereby the flip book prototype was created with the help of a digital publishing software. It was designed to include learning materials, illustrations, animations, simulations, and components of formative assessment as per the approved design. After the completion of the first prototype, expert validation was done to facilitate academic rigor and technical sufficiency. The subject-matter experts, media design specialists, and seasoned elementary school teachers were also used in the validation process where they tested the product based on content accuracy, instructional relevance, visual consistency, interactivity, and usability. Besides numerical ratings, the validators also made their comments and recommendations on how to improve in writing. The qualitative inputs were analyzed in a systematic manner and implemented to make amendments in the flipbook, which led to a perfected version meeting the set feasibility standards.

The implementation phase was undertaken after the development and revision phases and was carried out to test how the flipbook would perform in real classroom setting. The implementation was conducted in two phases in success, one as a pilot and another as large-scale. The small cohort was used in the limited trial that was meant to highlight the technical challenges, navigation challenges and first-time learning reactions. Responses to this step were used to make more changes to the product. The trial was a large-scale study that included 250 grade five students across eight elementary schools chosen using purposive sampling with the study conditions including institutional readiness, teacher willingness, and the presence of basic digital infrastructures. In classroom implementation, the flipbook was introduced into the regular science lessons, but the processes of teaching and interaction between teachers and students were monitored by the researchers.

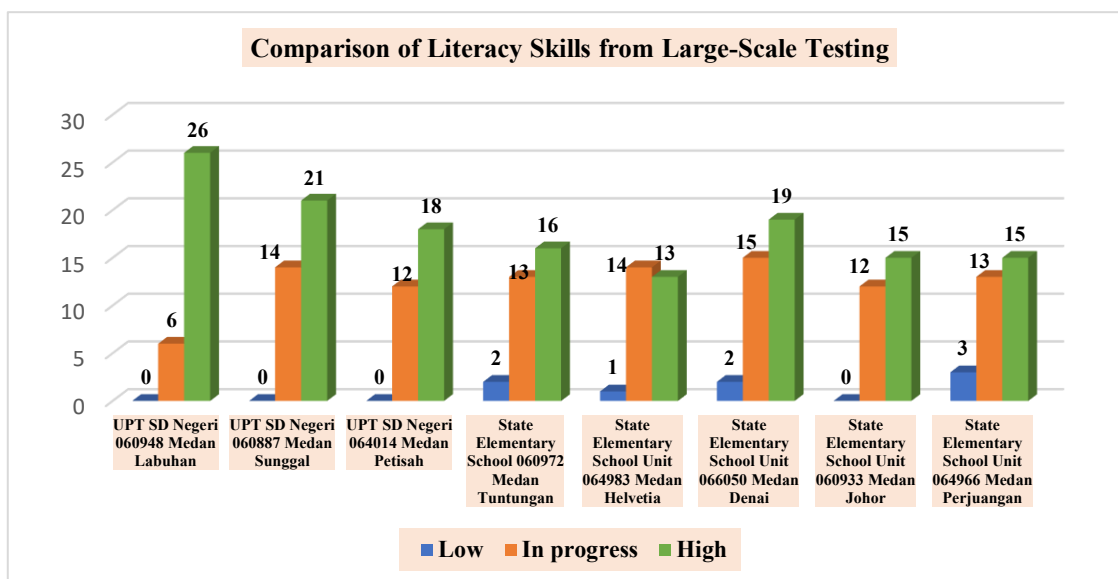
A set of data-collection methods were used to measure both outcomes of learning and experiential data during the implementation stage. Teachers and students were given questionnaires to determine their perceived practicality, ease of use, and instructional relevance. Interviews were semi-structured to bring out more insights on the perceptions, challenges, and suggestions of the participants. Observations in the classroom recorded student engagement, collaborative behavior and problem solving. There were also science literacy tests given at the beginning and the end of the intervention which assessed the changes in conceptual knowledge, logical thinking and skill making among the students. The review of experts based on the validated science literacy indicators and reviewed the assessment instruments on the basis of content validity and consistency with learning objectives.

Evaluation was the final research process which was meant to ascertain the overall standard of the developed flipbook as of feasibility, practicality, and effectiveness. The results of the expert validation were used as a means of feasibility measurement, which evaluates the academic and technical appropriateness of the product. Practicality was evaluated based on the teacher and student responses and also based on observational data in the class regarding the classroom integration. The effectiveness was studied through pre-test/ post-test design in which the learning gains were measured after exposure to the flipbook. Descriptive statistics and paired-sample t-tests were used to analyze quantitative data at 0.05 level of significance. Some measures like mean scores, standard deviations, correlation coefficients, and confidence intervals were calculated to facilitate systematic interpretation. Interpretations and observations of qualitative data were done to assist in supplementing the statistical results

Results and Discussion

The results of large-scale trials conducted in eight elementary schools in Medan City show that flipbooks based on science literacy integrated with sustainable lifestyles are effective in improving students' science literacy skills. In general, the distribution of student ability categories was at a moderate to high level, while the low category only appeared in a small number of schools with a relatively small percentage, ranging from 3.6% to 9.7%. Most students achieved the high category, for example, 81.2% of students at UPT SD Negeri 060948 Medan Labuhan, 60% at UPT SD Negeri 060887 Medan Sunggal, and 60% at UPT SD Negeri 064014 Medan Petisah. Other schools such as UPT SD Negeri 060972 Medan Tuntungan, UPT SD Negeri 066050 Medan Denai, UPT SD Negeri 060933 Medan Johor, UPT SD Negeri 064983 Medan Helvetia, and UPT SD Negeri 064966 Medan Perjuangan also showed a relatively similar pattern, where the majority of students were in the medium and high categories. This proves that the flipbook developed is not only able to maintain its effectiveness since the small-scale trial, but also reliable in its application on a larger scale. The variation in abilities among students indicates differences in their background understanding, but the

flipbook still functions as a medium that encourages an equitable improvement in science literacy. Thus, it can be concluded that this flipbook is suitable for use as an innovative learning medium to equip students with critical thinking skills, scientific skills, and awareness of a sustainable lifestyle from an early age.



Based on the comparison diagram of science literacy abilities from a large-scale trial in eight schools, it can be seen that the majority of students are in the high category, while the low category is only found in a few schools with a relatively small number of students. This shows a consistent increase in students' science literacy abilities after using the flipbook (Aji et al., 2022). The variation of students in the medium category indicates the need for additional guidance for some students, but overall, flipbooks are able to encourage an increase in science literacy skills (Purwandari et al., 2024).

These findings confirm that the developed flipbook is effective in improving students' science literacy skills, while also supporting their understanding of sustainable lifestyles. The use of *flipbooks* has been proven to equip students with science literacy knowledge and skills that are relevant to their daily lives, thereby supporting the creation of critical thinking and awareness of sustainability principles from elementary school age.

Product Feasibility

The feasibility of the flipbook was obtained through validation conducted by subject matter experts and media experts. The assessment results showed that the overall average score reached 4.35, which is classified as *highly feasible*. Subject matter experts assessed that the content was in accordance with science literacy indicators, accurate, and relevant to elementary school learning. Meanwhile, media experts assessed that the flipbook's appearance, navigation, and interactivity were attractive and easy to use. Thus, in terms of feasibility, the flipbook has met the standards as a learning medium (Ramadanti & Bektiningsih, 2023).

Practicality of the Product

The practicality of the *flipbook* was determined through trials with teachers and students. The teacher questionnaire showed an average score of 4.20, which falls into the *practical* category. In addition, the student questionnaire results showed that 85% stated that the flipbook was easy to understand, helpful in learning science literacy, and interesting to use. These findings indicate that the flipbook is practical for use in classroom learning.

Product Effectiveness

To determine the effectiveness of the flipbook in improving students' science literacy skills, a comparison of the initial and final test results was conducted. The results of the paired samples statistics analysis are presented in the following table:

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Initial Science Literacy Test	42.45	250	18.849	1,192
	Final Science Literacy Test	69.20	250	12,977	.821

Based on the results of descriptive statistical tests on paired samples statistics, there was a significant increase in students' science literacy skills after participating in flipbook-based learning. Before using flipbooks, the average science literacy skill of students was only 42.45 with a relatively high standard deviation of 18.849. This condition shows that the initial skills of students were still relatively low and varied. After learning with the use of flipbooks, the average science literacy ability increased to 69.20 with a lower standard deviation of 12.977. This increase of 26.75 points indicates that flipbooks have a positive effect on students' science literacy abilities.

In addition, the decrease in standard deviation from the initial test to the final test also shows that student learning outcomes became more evenly distributed and stable. This means that flipbooks not only help improve average achievement, but also minimize gaps between students. Thus, it can be concluded that flipbooks are an effective learning medium in improving science literacy, both in terms of increasing average scores and equalizing student learning outcomes.

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Initial Science Literacy Test & Final Science Literacy Test	250	.173	.006

Based on the results of paired samples correlations, a correlation value of 0.173 was obtained with a significance level of 0.006. A positive correlation value indicates a direct relationship between the initial and final tests of students' science literacy skills. This means that students who initially had relatively better science literacy skills tended to also obtain good results after learning with flipbooks. Although the correlation value is relatively low, it is still significant because the significance value is below 0.05.

This confirms that the initial test results are indeed related to the final test, but the improvement that occurs does not entirely depend on the students' initial abilities. The role of flipbooks as a learning medium contributes significantly to encouraging an overall improvement in science literacy. In other words, flipbooks are able to help even students with low abilities to experience significant improvement.

Thus, the significant correlation between the initial and final tests shows the continuity of the learning process, but the effectiveness of the flipbook is evident because the improvement in learning outcomes is not only experienced by students who already have high initial abilities, but also by students with moderate to low initial abilities.

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Initial Science Literacy Test - Final Science Literacy Test	-26.744	20,948	1,325	-29,353	-24,135	-20,186	249	.000

Based on the results of the paired samples test, the mean difference value obtained was -26.744. The negative sign indicates that the final science literacy test score was much higher than the initial test score. The standard deviation of the difference is 20.948 with a standard error mean of 1.325. The 95% confidence interval is in the range of -29.353 to -24.135, which means that the average difference is consistently in the negative range, thus strengthening the evidence of a significant improvement.

Furthermore, the t-value is -20.186 with $df = 249$ and a significance level (sig. 2-tailed) = 0.000. Since the significance value is less than 0.05, it can be concluded that there is a very significant difference between the initial and final science literacy tests.

These findings confirm that the use of flipbooks is effective in improving students' science literacy skills. Not only is the average increase large, but statistically this increase is significant and does not occur by chance. Thus, flipbooks can be declared a feasible learning medium that successfully helps students achieve better learning outcomes in science literacy.

The results of the study show that the science literacy flipbook based on a sustainable lifestyle that was developed meets the criteria of being highly feasible, practical, and effective. This is in line with the research development objectives that emphasize the importance of innovative learning media to support the achievement of science literacy in elementary school students.

In terms of feasibility, the results of validation by subject matter experts and media experts showed a highly feasible category. These findings indicate that the flipbook is suitable for students' needs in terms of content, material accuracy, and display design. According to learning media development theory, validation by experts is an important step to ensure that the developed product is relevant to learning competencies and suits the characteristics of the students (Rahmadani & Bungawati, 2024).

From a practical standpoint, the results of trials involving teachers and students showed that flipbooks are easy to use, interesting, and useful. The teacher questionnaire received an average score of 4.20 in the practical category, while student responses showed that 85% felt that flipbooks helped them understand the material. This reinforces the opinion that practical learning media will increase student engagement in the learning process, thereby supporting learning effectiveness.

From an effectiveness perspective, the trial was conducted in two stages, namely a small-scale trial and a large-scale trial.

In the small-scale trial, the flipbook was applied to a limited number of students. The results showed that most students experienced an increase from the moderate category to the high category. This indicates that the flipbook can have a positive impact even when applied to a small group, and provides initial input for product refinement before widespread application.

In the large-scale trial, the flipbook was used on a larger number of students, and the results showed a more significant improvement. The majority of students were in the high category after using the flipbook, and the results of the paired sample t-test showed a significance value of $0.000 < 0.05$. These results prove that the flipbook is effective in improving students' science literacy on a broader learning scale.

The findings from the small-scale and large-scale trials are in line with technology-based learning theory, which states that interactive digital media can facilitate critical thinking skills, conceptual understanding, and students' science literacy. These findings also support previous research showing that digital flipbooks can increase student motivation and learning outcomes due to their interactive, engaging, and accessible nature.

Overall, this discussion shows that the sustainable lifestyle-based science literacy flipbook that was developed not only fulfills theoretical and practical aspects but is also empirically proven to be effective in both small-scale and large-scale trials. Thus, this product can be used as an alternative innovative learning medium that is relevant to the demands of 21st-century education, particularly in building students' awareness of the importance of a sustainable lifestyle.

Conclusion

The flipbook design developed in this study was compiled by combining science literacy material integrated with 21st-century sustainable lifestyle values. The design process was carried out systematically through the stages of needs analysis, flowchart preparation, storyboarding, and science literacy indicator mapping, resulting in interactive, contextual learning media suitable for elementary school students. In terms of feasibility, the flipbook was declared feasible to highly feasible based on assessments by subject matter experts, media experts, and practitioners or teachers. The assessment covered aspects of content suitability, material accuracy, visual appearance, navigation, interactivity, and ease of use, proving that the flipbook is relevant to the needs of students while supporting the integration of 21st-century sustainable lifestyle values. The effectiveness of using flipbooks has been proven to be significant in improving students' science literacy. This is reflected in the statistical test results, which show an increase in the average score from 42.45 in the initial test to 69.20 in the final test, with a difference of 26.75 points. The t-test results also show a significant difference ($t = -20.186$; $\text{sig.} = 0.000$), so it can be concluded that flipbooks are not only effective in improving science literacy achievement but also capable of reducing the learning gap between students.

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